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TO BARKBEETLE ATTACK

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Does the western pine beetle attack and kill trees indiscriminately, or does it show a decided preference for certain types of yellow pines? The answer to this question has a decidedly practical application, viz.: if the type of trees susceptible to beetle attack is known, they can be removed during selective logging and the subsequent loss from this source reduced. Further, knowing the type of trees selected by beetles for their attack, any given tract of timber can be judged as to the risk of heavy beetle losses occurring in it, simply by estimating the proportion of beetle-susceptible trees in the stand. This question has puzzled foresters and forest entomologists for some time, and only recently has considerable light been thrown upon the subject.

Person, in 1926, made an intensive study of an area of about four sections near Northfork, California, and found that "the loss from D.b. per unit area varied inversely with the quality of the site, the heaviest losses being found on the poorest sites; that there appeared to be no well-defined relation between shape of crown and selection by the beetles except that sharp-pointed trees were avoided and flat-topped trees preferred to some extent; that a decided preference was shown for trees between 20 and 30" d.b.h., and that the beetles selected the more slowly-growing trees in 75 per cent of the cases studied."

The surveys on the Southern Oregon-Northern California Project, which started in 1921, have accumulated considerable data on the size, growth rate and crown classes of trees killed by barkbeetles--mainly the western pine beetle (Dendroctonus brevicomis Lec.). Each year some 50 permanent sample plots, mostly of 640 acres each and scattered throughout about 2000 square miles of the yellow pine stands of the east side type, have been intensively cruised. A three-man crew, consisting of two spotters and a compassman, run two strips through each forty. The spotters, working in a five-chain strip on each side of the compassman, cover 100 per cent of the plot and mark up all the current year's beetle loss. During the survey of 1927, 47 plots totaling 19,680 acres were covered in this manner, and in addition to the usual data all the trees killed by beetles during 1926 were tallied as to their tree class. In addition, on each plot the compassman tallied all the green trees falling within a 13.2-foot strip (2 per cent estimate) along his line, and tabulated them as to tree class and diameter. With the completion of this survey we have a sample consisting of 10,053 green trees and 13,160 beetle-killed trees, classified as to tree class and diameter and representing a wide range of conditions as to site, exposure, soil and elevation. With such a basis we have a very good index as to the class of trees selected by the western pine beetle in the timber type of this region.

TREE CLASSIFICATION

Early in 1927, Duncan Dunning of the California Forest Experiment Station proposed a tree classification for western yellow pine based upon age, degree of dominance, crown development and thrift. Taking the sum of these characteristics, seven classes were defined as follows:

CLASS 1 Age class, young or thrifty mature; position, isolated or dominant (rarely co-dominant; crown length, 65 per cent or more of total height; crown width, average or wider; form of top, pointed; vigor, good (pl. I, fig. 1).

CLASS 2 Age class, young or thrifty mature; position, usually co-dominant (rarely isolated or dominant); crown length, less than 65 per cent of the total height; crown width, average or narrower; form of top, pointed; vigor, good or moderate (pl. I, fig. 2).

CLASS 3 Age class, mature; position, isolated or dominant (rarely co-dominant); crown length, 65 per cent or more of total height; crown width, average or wider; form of top, round; vigor, moderate (pl. I, fig. 3).

CLASS 4 Age class, mature; position, usually co-dominant (rarely isolater or dominant); crown length, less than 65 per cent of total height; crown width, average or narrower; form of top, round; vigor, moderate or poor (pl. I, fig. 4).

CLASS 5 Age class, overmature; position, isolated or dominant (rarely co-dominant; crown, of any size; form of top, flat; vigor, poor (pl. I, fig. 5).

CLASS 6 Age class, young or thrifty mature; position, intermediate or suppressed; crown, of any size, usually small; form of top, round or pointed; vigor, moderate or poor (pl. I, fig. 6).

CLASS 7 Age class, mature or overmature; position, intermediate or suppressed; crown, of any size, usually small; form of top, flat; vigor, poor (pl. I, fig. 7).

TREE CLASSES SELECTED

Classifying all the trees killed by beetles in 1926 and 2 per cent of the green trees on all the sample plots, we find that the average distribution of the trees in these classes within the stand is as shown in Plate II. Throughout southern Oregon and northern California, in the east-side yellow-pine type, overmature pines of Class 5 form over 32 per cent of the stand; vigorous trees of Class 1 are the next in order of abundance and represent 22 per cent of the stand; Class 3 is next in order; and the smallest number of trees, representing 4 per cent of the stand, fall in Class 7.

Forty-five per cent of the beetle losses by trees occur in Class 5, twenty per cent in Class 4 and the smallest per cent in Classes 1 and 6. Naturally, since Class 5 has the trees of largest diameter, the big volume of loss occurs in trees of this class.

Taking into account the number of trees of each class in the stand and the frequency with which such trees are attacked by beetles, we have the graph shown in Plate III.

In order to determine whether certain classes of trees are more susceptible to insect attack than other classes, it is necessary to compare the frequency with which the different classes are attacked. If no selection was made by the beetles we should expect to find the distribution of beetle losses in proportion to the occurrence of the different classes within the stand. On Plate III is graphed the ratio of the beetle losses in different tree classes to the occurrence of these classes in the stand. A ratio of 1 to 1 indicates an even distribution and no selection. A ratio of less than 1 indicates avoidance, and of more than 1 a preference. This graph therefore brings out a very decided preference on the part of the beetles for trees of Classes 7, 4 and 5 in the order named, and an avoidance of trees in Classes 1, 3, 2 and 6, also in the order named. Class 7 trees are killed 2.25 times as frequently as they should be if an even distribution of losses occurred, and Class 1 trees only one-quarter as often.

It was quite a surprise to find such a preference shown for Class 7 trees, since beetle-killed trees of this class are not frequently encountered. But this is simply because the green trees of this class form only 4 per cent of the stand, and hence are inconspicuous in numbers.

The fact that Class 4 trees are more frequently killed than Class 5 is another interesting point that is contrary to the impression secured from general observation. However, it is entirely logical that it should be so, since the mature co-dominate trees of this class are the ones suffering from the greatest competition, while trees of Class 5 are usually isolated dominants which have secured a good foothold and have plenty of ground space to draw upon for their moisture supply.

The trees of these three susceptible classes, according to studies by Dunning, all show annual growth rates of less than 1 per cent of the basal area, even on the better sites, which ties in well with other studies as to the preference of the beetles for slow-growing trees. Some interesting relationships between the volumes of beetle-killed trees and trees in the stand are brought out in Plate IV.

On comparing the distribution of the board-foot volumes in the seven tree classes, it is foundtthat on the check plots of Area 1 over 80 per cent of the volume occurs in the overmature dominants of Class 5. On Area 2, 65 per cent of the volume is found in this class (pl. IV, figs. 1 and 4), and on both areas over 80 per cent of the volume of beetle loss occurs in this class. The other classes represent a comparatively small proportion of the volume.

However, on comparing the frequency of the beetle losses by volume in the different tree classes with the occurrence of these volumes in the classes for the stand as a whole, we find the same selection of tree classes as is shown in Plate III, when this comparison was made on the tree basis. Again we find that Class 7 is the greatest risk, Class 4 the next in importance, while only a slight preference is shown for Class 5 trees.

On comparing the average volume of live and killed trees by classes, another suggestive point is brought out (pl. IV, fig. 3). Classes 2, 4, 6 and 7, which include all the co-dominant, intermediate and suppressed trees, show almost the same average volume for beetle-killed as for green trees. This indicates that within these classes no particular selection of large or small individuals is shown by the beetles. However, for the dominant trees of Classes 1, 3 and 5, the average volume of the killed trees is uniformly lower than that of the stand as a whole; which means that when the beetles do kill trees of these dominant classes they select the undersized individuals, which are probably less resistant than the average of their class. This point is most significant.

In Plate V, this same ratio of occurrence of tree classes in insect losses to the occurrence in the stand is shown for the four areas of the Southern Oregon-Northern California region. In every case practically the same ratios hold as for the combined results, which shows that the basis is an entirely adequate one for definite conclusions and that the same selective habits of the beetles hold throughout this region.

However, we note some slight variations on these different areas. For instance, on Area 2, Class 4 trees are not so prominently susceptible as in the general case; on Area 3, Class 2 trees show some slight degree of susceptibility, and on the Modoc area Class 7 trees are outranked by Class 4. To determine if these variations are due to different site conditions the data have been rearranged according to site.

SELECTION OF TREE CLASSES ON VARIOUS SITES

Plate VI shows the distribution of green trees and beetle-killed trees on Sites 2, 3, 4 and 5. No plot running to Site 1 was available on the area. This chart shows about the same distribution of trees by tree classes on all sites, without any striking differences. But when we compare the ratio of beetle-killed trees to the total trees in the stand on the different sites, some striking differences are brought out.

Thus in Plate VII on Site 2 we find a very pronounced selection of 4's and 7's, the co-dominant, intermediate and suppressed trees of the mature and overmature age classes. Overmature trees of Class 5 on this site are able to maintain themselves, and hense are only slightly susceptible.

On Site 3 we still have a strong preference shown for 4's and 7's. On Site 4, which forms the bulk of the pine stand in this region, we have the same preference for 4's, 5's and 7's as was brought out in Plate III for the stand as a whole. On Site 5 we find that Class 5 has a hard struggle, and the preference of the beetles is about equally divided between 4's, 5's and 7's.

Using these same figures and plotting the trees of each class according to site and per cent of stand killed, certain interesting sidelights are brought out (Plate VIII).

Trees of Class 1 form from 18.1 per cent to 24.6 per cent of the stand on the various sites. They form a higher per cent of the stand on poor sites than on good ones, showing that on good sites most of the other and older tree classes survive to form a large part of the stand, while on poor sites the older trees are more frequently killed, with a higher proportion of Class 1 trees surviving. Only from 1.7 to 5.4 per cent of the beetle loss is found in trees of this class, with a higher percentage of such trees killed on the poor sites than on the good ones.

Class 2 trees form from 9.1 to 12.8 per cent of the stand, and in beetle losses they represent from 6.7 to 9.7 per cent of the total loss. There does not appear to be any marked difference in the occurrence of such trees or the losses by sites.

Trees of Class 3 show the same tendency as trees of Class 1. As the site gets poorer they form a larger percentage of the stand, due to the greater elimination of less dominant trees. The beetle losses also increase in this class as the site gets poorer, but still do not occur as frequently as do the trees in the stand.

For trees of Class 4, we see that on every site they appear more frequently in the beetle losses than they do in the stand as a whole. However, as the site gets poorer the proportion of Class 4 trees consistently decreases. This is because on the better sites there is a greater difference in the growth rate, and thus of susceptibility, than on the poorer sites. On the latter all classes of trees tend to become susceptible, and thus a smaller percentage of the losses fall in any particular tree class.

For trees of Class 5, the beetle losses in every case appear more frequently than these trees occur in the stand, and the ratio of loss increases steadily as the site becomes poorer. The percentage of green trees in this class varies from 38.1 per cent on Site 2 to 29.0 per cent on Site 5. This indicates that the overmature trees of this class maintain themselves longer on a good site than they do on a poor one, and hence form a higher percentage of the total stand. As would be expected, the beetle losses are increasingly greater on the poorer sites.

Trees of Class 6 represent only a very small percentage of the stand, varying from 7.2 per cent on Site 2 to 3.5 per cent on Site 5. The beetles do not show any particular preference for these trees and kill a varying proportion on the different sites.

Trees of Class 7 also form only a small percentage of the stand, running around 4 to 5 per cent for all sites. The beetle losses in every case occur with greater frequency in this class than they would if an even distribution of loss occurred. The competition and hence beetle loss appear to be greater for trees on the good sites than on the poor ones.

SELECTION OF TREES BY DIAMETER GROUPS

The samples of green trees and all the beetle-killed trees of the 1926 loss were also compared as to diameters.

Plate IX, fig. 1, shows by diameter classes the normal distribution of trees in the stand and those beetle-killed. This curve is similar in every way to the one found in the study by Person and Sanford. The big bulk of the infestation occurs in the diameter groups between 16 and 28 inches. In Fig. 2 is determined the ratio of occurrence of beetle-killed trees to that of trees in the stand for each diameter class. This graph shows a definite selection by the beetles of trees between 16 and 28 inches d.b.h., while in the diameter classes above 28 inches they kill about as frequently or less frequently than these trees occur in the stand, and hence cannot be considered as showing any preference.

Why should the beetles select trees between these diameter limits? In general it would seem reasonable that trees falling between these limits include most of the trees suffering from severe competition. The bulk of trees below 16 inches are young, thrifty and fast-growing, while the majority over 28 inches have reached a dominant position in the stand, crowded out their nearest neighbors, and are now in a better position to survive than trees of smaller diameters.

Working on this theory the tree classes of each diameter group were plotted to show the percentage of green and killed trees in each class.

Referring to Plate X, Fig. 1, we see that of trees 16 inches d.b.h., 56 per cent are young or young thrifty trees of Class 1 and 26 per cent are young co-dominants of Class 2. These two classes together form 82 per cent of the stand. All other classes are inferior trees for this diameter, and hence are the ones suffering from the greatest beetle loss.

In trees of 18 inches d.b.h., Class 1 forms 36 per cent of the stand, and 21 per cent now come in Class 3, which is beginning to be an important tree class for this diameter group. Here the bulk of the beetle loss occurs in trees that are struggling to survive--co-dominant matures, overmatures and mature suppressed. By the time the trees have reached 20 inches d.b.h., Class 3 forms the greater part of the stand, Class 4 is also prominent, and Class 1 has subsided to a little over 21; and it is in the three classes 3, 4 and 5 that the big struggle with the insects is occurring with a particularly high mortality in trees that have become overmature at this size.

In diameter groups 22 inches and 24 inches the same factors are evident, with Class 5 becoming increasingly important. With diameter 26 inches Class 5 becomes the most conspicuous class, and 67 per cent of the beetle loss falls here. By the time diameter 30 inches is reached, 67 per cent of the green trees and 86 per cent of the beetle losses occur in the overmature trees of Class 5, and for trees larger than 30 inches the beetle loss is confined almost entirely to this, since it is about the only class represented in the stand.

The evidence therefore supports the theory that the reason trees between 16 and 28 inches are selected is because the greatest struggle of the mature co-dominants is occurring in these diameter classes. After the trees reach 28 inches the bulk of trees in the stand is made up of overmature dominants that are fairly well fitted to survive.

So far all this study pertains to conditions as they existed in a year of epidemic infestation like 1926. Whether under endemic infestation conditions would be markedly different cannot well be determined until we have an endemic situation on this area. However, in 1923 the infestation was as nearly endemic as it is ever apt to be in this region. A study of the diameter groups selected by the beetles in 1923 as compared to those selected in 1926 is given in Plate XI. This shows that during the endemic year of 1923 the selection of trees between 16 and 32 inches was even more pronounced than in 1926, during the epidemic year. In both years the percentage of trees selected over 32 inches d.b.h. is about the same as the percentage of such trees in the stand, indicating that no preference was shown for these large trees, but that they were killed in about the same ratio as their occurrence in the stand.

APPLICATION OF RESULTS

Since it is evident that certain trees are more susceptible than others to barkbeetle attack, the question arises as to what will happen if the susceptible trees are removed from the forest through selective thinning. There are two alternatives: either the beetles will ignore their preferences and select supposedly less susceptible trees or they will die out because of the reduction in their normal food supply.

If the beetles disregard their preferences when a shortage of susceptible trees exists, we should expect to find them attacking all classes of trees on the better sites. Instead, however, the loss on the better sites is low and preference for the few available susceptible trees extremely well marked. If these few susceptible trees were removed we should expect to find a further reduction in the losses.

Since on the poorer sites nearly all classes of trees are susceptible, we should not expect to get such beneficial results from thinning. However, even here a thinning by reducing competition between individual trees and groups of trees should increase the vigor of the remaining stand and help to reduce the beetle losses.

The selective logging of a beetle-infested area, with removal of the more susceptible trees, should result in marked improvement in the vigor and resistance of the stand and reduce beetle losses to a minimum. However, in most of the virgin western yellow pine stands of southern Oregon and northern California, from 65 to 80 per cent of the volume of the stand is in overmature trees. The removal of susceptible trees on such areas would mean about as heavy cutting as is now practised on commercial logging operations in this region.

SUMMARY

A study of a large series of green and beetle-killed western yellow pines in southern Oregon and northern California shows that the western pine beetle in this region exhibits a decided preference for overmature suppressed trees of Class 7, mature co-dominant trees of Class 4 and overmature dominant trees of Class 5.

The classes of trees selected are all making an annual growth of less than one per cent of the basal area.

On the areas studied, from 65 to 80 per cent of the stand and 80 per cent of the loss by volume consists of the overmature dominant trees of Class 5.

Within the co-dominant, intermediate and suppressed classes, the beetles show no selection as to size of the individuals. In the dominant classes, the average volume of trees killed by beetles is much lower than the average volume of the class as a whole.

Poor sites show a greater loss than good sites. On the poorest sites the selective tendency becomes less marked, the trees of all classes being reduced to such a low stage of vigor as to become susceptible to attack. On good sites there is a very marked selection of the suppressed and co-dominant trees of Classes 4 and 7.

As the site becomes poorer the proportion of loss increases in the dominant classes 1, 3 and 5, and decreases in the co-dominant, intermediate and suppressed classes 2, 4, 6 and 7.

The beetles show a preference for trees of the diameter classes between 16 and 32 inches d.b.h. This is principally due to the high proportion of trees struggling for dominance within this diameter range.

During endemic conditions the selection of trees within these diameter limits (16 to 32 inches) is even more marked than during epidemic conditions.

The results of this study emphasize the importance of marking for removal trees of classes 4, 5 and 7. It also indicates that perhaps more smaller-diameter trees in Classes 4, 5 and 7 should be removed than has heretofore been the practice. Class 3 trees are the safest risk where large trees are needed for seed or where a reserve volume of valuable material is desired. Class 2 trees are a relatively poor risk, and should be removed in preference to Class 1 trees where groups are to be thinned.

The selective thinning of stands, with the removal of beetle-susceptible trees, offers hope of greatly reducing the loss from insects, especially on the better sites.

TABLE 1.-Data for Plates 2 and 3

	1	2	3	4	5	6	7	Total
Green Trees on Strips	2,227	1,003	1,514	1,154	3,147	605	405	10,055
Total Green on Plots	111,350	50,150	75,700	57,700	157,350	30,250	20,150	502,650
Beetle-Killed	657	913	1,256	2,567	5,930	652	1,185	13,160
Total	112,007	51,063	76,956	60,267	163,280	30,902	21,335	515,810
Per cent Occurrence	21.7	9.9	14.9	11.7	31.7	6.0	4.1	100%
Per cent Occurrence of Killed	5.0	6.9	9.5	19.5	45.0	4.9	9.0	100%
Per cent of Stand Killed	.59	1.78	1.63	4.26	3.63	2.11	5.55	2.55
Ratio of Occurrence	.23	.70	.64	1.67	1.42	.82	2.20	1

TABLE 2.--Data for Plate 5

	1	2	3	4	5	6	7	Total
Green Trees in Strips	583	343	293	363	1,141	127	132	2,982
Green Trees on Plots	29,150	17,150	14,650	18,150	57,050	6,350	6,600	149,100
Beetle-Killed (1926)	79	100	125	438	871	19	192	1,824
Total	29,229	17,250	14,775	18,588	57,921	6,369	6,792	150,924
Per cent Occurrence in Stand	19.4	11.4	9.8	12.3	38.4	4.2	4.5	100%
Per cent Occur. Killed 1926	4.3	5.5	6.9	24.0	47.8	1.0	10.5	100%
Ratio	.22	.48	.70	1.95	1.24	.24	2.34	1
AREA 2								
Green	447	196	493	332	585	162	105	2,320
Green on Plots	22,350	9,800	24,650	16,600	29,250	8,100	5,250	116,000
Beetle-Killed	309	231	598	918	2,371	240	500	5,167
Total	22,659	10,031	25,248	17,518	31,621	8,340	5,750	121,167
Per cent Stand	18.7	8.3	20.8	14.5	26.1	6.9	4.7	100%
Per cent Killed	6.0	4.5	11.6	17.8	45.8	4.6	9.7	100%
Ratio	.32	.54	.56	1.23	1.75	.67	2.06	1
AREA 3								
Green Strip	734	303	564	333	1,016	244	110	3,304
Plot	36,700	15,150	28,200	16,650	50,800	12,200	5,500	165,200
Killed	241	515	430	984	2,167	349	400	5,086
Total	36,941	15,665	28,630	17,634	52,967	12,549	5,900	170,286
Per cent Stand	21.6	9.2	16.8	10.4	31.1	7.4	3.5	100%
Per cent Killed	4.7	10.1	8.4	19.3	42.7	6.9	7.9	100%
Ratio	.22	1.10	.50	1.86	1.37	.93	2.26	1
MODOC								
Green Strip	463	161	164	126	405	72	56	1,447
Green on Plots	23,150	8,050	8,200	6,300	20,250	3,600	2,800	72,350
Killed	28	67	103	227	521	44	93	1,083
Total	23,178	8,117	8,303	6,527	20,771	3,644	2,893	73,433
Per cent Stand	31.5	11.1	11.3	8.9	28.3	5.0	3.9	100%
Per cent killed	2.6	6.2	9.5	21.0	48.1	4.0	8.6	100%
Ratio	.08	.56	.84	2.36	1.70	.80	2.21	1

TABLE 3.—Data for Plates 6, 7 and 8

SITE II

	1	2	3	4	5	6	7	Total
Green Trees on Strips	138	88	58	63	260	49	27	683
Total Green on Plots	6,900	4,400	2,900	3,150	13,000	2,450	1,350	34,150
Beetle-Killed	3	17	4	48	72	12	20	176
Total	6,903	4,417	2,904	3,198	13,072	2,462	1,370	34,326
Per cent Stand	20.1	12.8	8.5	9.3	38.1	7.2	4.0	100%
Per cent Killed	1.7	9.7	2.3	27.2	40.9	6.8	11.4	100%
Ratio	.08	.76	.27	2.92	1.07	.95	2.85	

SITE III

	1	2	3	4	5	6	7	Total
Green Trees on Strips	311	203	161	226	616	103	85	1,705
Total Green on Plots	15,550	10,150	8,050	11,300	30,800	5,150	4,150	85,150
Beetle-Killed	14	50	49	186	305	17	124	745
Total	15,564	10,200	8,099	11,486	31,105	5,167	4,274	85,895
Per cent Stand	18.1	11.9	9.4	13.4	36.2	6.0	5.0	100%
Per cent Killed	1.9	6.7	6.6	24.9	41.0	2.3	16.6	100%
Ratio	.10	.56	.70	1.86	1.13	.38	3.32	

SITE IV

	1	2	3	4	5	6	7	Total
Green Trees on Strips	1,669	668	1,218	820	2,151	433	276	7,240
Total Green on Plots	83,450	33,400	60,900	41,000	107,550	21,900	13,800	362,000
Beetle-Killed	616	778	1,095	2,174	5,100	593	978	11,334
Total	84,066	34,178	61,995	43,174	112,650	22,493	14,778	373,334
Per cent Stand	22.5	9.1	16.6	11.6	30.2	6.0	4.0	100%
Per cent Killed	5.4	6.9	9.7	19.2	45.0	5.2	8.6	100%
Ratio	.24	.76	.58	1.66	1.49	.87	2.15	

SITE V

	1	2	3	4	5	6	7	Total
Green Trees on Strips	109	44	77	45	120	15	17	427
Total Green on Plots	5,450	2,200	3,850	2,250	6,000	750	850	21,350
Beetle-Killed	24	68	108	159	453	30	63	905
Total	5,474	2,268	3,958	2,409	6,453	780	915	22,255
Per cent Stand	24.6	10.2	17.8	10.8	29.0	3.5	4.1	100%
Per cent Killed	2.6	7.5	12.0	17.6	50.0	3.3	7.0	100%
Ratio	.10	.74	.67	1.63	1.72	.94	1.71	

TABLE 4.--Data for Plate IX

Distribution of Trees by Diameter Classes

	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66		
Green Strip	893	926	840	666	778	737	744	737	696	702	625	481	366	292	229	144	83	59	41	47	32	15	13	14	9	4	2	1	1		
Green Plots	44,650	46,300	42,000	33,300	38,900	36,850	37,200	36,850	34,800	35,100	31,250	24,050	19,300	14,600	11,450	7,200	4,150	2,950	2,050	2,350	1,600	750	650	700	450	200	100	50	50	Total Green	509,850
Killed	688	1,044	1,085	1,047	1,203	1,239	1,196	1,512	1,251	1,015	698	641	523	265	238	134	110	88	57	41	30	21	15	6	2	4	2	0	0	Total Killed	14,153
Total	45,338	47,344	43,085	34,347	40,103	38,089	38,396	38,362	36,051	36,115	31,948	24,691	19,823	14,865	11,688	7,334	4,260	3,038	2,107	2,391	1,630	771	665	706	452	204	102	50	50	Total on Plot	524,003
Per ct. Stand	8.65	9.03	8.21	6.55	7.64	7.26	7.33	7.32	6.88	6.89	6.10	4.72	3.79	2.84	2.24	1.40	.81	.58	.41	.46	.31	.15	.13	.13	.09	.04	.02	.01	.01		
Per ct. Killed	4.86	7.38	7.66	7.39	8.51	8.75	8.45	10.71	8.86	7.18	4.94	4.54	3.69	1.86	1.68	.96	.78	.62	.41	.30	.22	.15	.10								
Ratio	.56	.82	.93	1.13	1.11	1.21	1.15	1.46	1.29	1.04	.81	.96	.98	.66	.75	.69	.96	1.07	1.00	.65	.71	1.00	.77								

TABLE 5.—Data for Plate X
Tree Classes

	1	2	3	4	5	6	7	Total
Diam. 16"								
Green Strips	372	170	1	4	0	21	75	643
Green Plots	18,600	8,500	50	200	0	1050	3,750	32,150
Beetle-Killed	77	170	129	248	80	50	233	987
Total	18,677	8,670	179	448	80	1,100	3,983	33,137
Per cent Stand	56.4	26.2	.5	1.4	.2	3.3	12.0	100%
Per cent Killed	7.7	17.2	13.1	25.2	8.1	5.1	23.6	100%
Diam. 18"								
Green Strips	284	108	162	135	4	4	59	756
Green Plots	14,200	5,400	8,100	6,750	200	200	2,950	37,800
Beetle-Killed	65	153	165	360	215	30	160	1,148
Total	14,265	5,553	8,265	7,110	415	230	3,110	38,948
Per cent Stand	36.6	14.3	21.2	18.2	1.1	.6	8.0	100%
Per cent Killed	5.7	13.3	14.4	31.3	18.7	2.6	14.0	100%
Diam. 20"								
Green Strips	160	52	222	213	82	0	3	732
Green Plots	8,000	2,600	11,100	10,650	4,100	0	150	36,600
Beetle-Killed	38	64	188	410	452	11	34	1,197
Total	8,038	2,664	11,288	11,060	4,552	11	184	37,797
Per cent Stand	21.3	7.1	29.8	29.3	12.0	.0	.5	100%
Per cent Killed	3.2	5.4	15.7	34.2	37.8	.9	2.8	100%
Diam. 22"								
Green Strips	87	20	228	229	155	0	0	719
Green Plots	4,350	1,000	11,400	11,450	7,750	0	0	35,950
Beetle-Killed	21	48	141	399	491	17	13	1,130
Total	4,371	1,048	11,541	11,849	8,241	17	13	37,080
Per cent Stand	11.8	2.8	31.1	32.1	22.2	0	0	100%
Per cent Killed	1.8	4.2	12.5	35.4	43.5	1.5	1.1	100%
	1	2	3	4	5	6	7	Total
Diam. 24"								
Green Strips	64	6	246	199	201	0	0	716
Green Plots	3,200	300	12,300	9,950	10,050	0	0	35,800
Beetle-Killed	15	17	144	449	745	57	7	1,434
Total	3,215	317	12,444	10,399	10,795	57	7	37,234
Per cent Stand	8.7	.8	33.4	27.9	29.0	.2	0	100%
Per cent Killed	1.0	1.2	10.0	31.4	51.9	4.0	.5	100%
Diam. 26"								
Green Strips	44	4	213	143	274			678
Green Plots	2,200	200	10,650	7,150	13,700			33,900
Beetle-Killed	4	7	99	245	791	30	4	1,180
Total	2,204	207	10,749	7,395	14,491	30	4	35,080
Per cent Stand	6.3	.6	30.6	21.1	41.3	.1	0	100%
Per cent Killed	.3	.6	8.4	20.8	67.1	2.5	.3	100%
Diam. 28"								
Green Strips	32	2	176	105	382	0	0	697
Green Plots	1,600	100	8,800	5,250	19,100	0	0	34,850
Beetle-Killed	6	3	63	159	729	0	0	960
Total	1,606	103	8,863	5,409	19,829	0	0	35,810
Per cent Stand	4.4	.3	24.8	15.1	55.4	0	0	100%
Per cent Killed	.6	.3	6.6	16.6	75.9	0	0	100%
Diam. 30"								
Green Strips	27	0	112	64	417	0	0	620
Green Plots	1,350	0	5,600	3,200	20,850	0	0	31,000
Beetle-Killed	2	1	30	53	553	0	0	639
Total	1,352	1	5,630	3,253	21,403	0	0	31,639
Present Stand	4.3	0	17.8	10.3	67.6	0	0	100%
Per cent Killed	.3	.2	4.7	8.3	86.5	0	0	100%

TABLE 6.—Data for Plate IV

Green

Unit	1 Trees	1 Volume	2 Trees	2 Volume	3 Trees	3 Volume	4 Trees	4 Volume	5 Trees	5 Volume	6 Trees	6 Volume	7 Trees	7 Volume
Antelope28	53	508	35	256	45	20,64	21	719	92	11,807	9	49	9	73
Ferguson33	44	295	19	113	49	16,22	25	884	47	6,727	-	-	13	130
Gerber 24	64	575	14	110	65	26,25	28	11,04	84	93,91	28	162	5	31
Goodlowe 5	58	643	16	166	79	39,84	52	22,37	152	192,28	41	255	18	118
Royston 10	44	767	25	269	51	30,98	53	44,40	21	35,69	22	151	7	70
Sycan 2	32	280	18	139	44	23,80	28	17,30	63	105,36	4	16	8	52
Willow 20	66	928	13	168	67	42,84	50	29,69	88	113,31	20	167	19	223
Total	361	39,96	138	12,21	400	200,57	257	140,83	547	725,89	124	800	79	697
x 50		1998,00		610,50		10028,50		7041,50		36294,50		400,00		348,50
Bugs		23,03		25,95		146,99		260,55		2007,12		17,13		38,48
Tot.Stand		2,021,03		636,45		10,175,49		7,302,05		38,301,62		417,13		386,98
Stand %		5.4		1.1		17.2		12.3		64.7		.7		.6
Beetles %		.9		1.0		5.8		10.3		79.8		.7		1.5

Total, 1896 trees

59,240,750 bd.ft.

TABLE 7.—Data for Plate IV

Area 2 - Bugs

Unit		1 Trees	1 Vol.	2 Trees	2 Vol.	3 Trees	3 Vol.	4 Trees	4 Vol.	5 Trees	5 Vol.	6 Trees	6 Vol	7 Trees	7 Vol.
Antelope	28	7	51	12	75	19	417	77	2341	149	14,491	6	32	31	293
Ferguson	35	25	207	10	55	106	3142	87	3587	421	41,700	7	30	57	448
Gerber	24	9	78	54	599	74	1597	97	2621	284	25,680	35	174	45	427
Goodlowe	5	14	82	27	410	13	286	46	1357	76	8,402	15	96	16	145
Royston	10	27	640	21	318	36	2204	77	3709	54	5,466	38	338	29	227
Sycan	2	45	266	15	58	159	2979	144	3495	768	76,343	28	138	115	1111
Willow	20	71	979	55	1080	99	4074	217	9145	376	28,630	76	905	86	1197
Total		198	2303	192	2595	506	14,699	745	26055	2128	200,712	203	1713	379	3848

Total - 4351 trees

2,519,250 bd.ft.

TABLE 8.--Data for Plate IV

Area 1 - Green Trees

		1		2		3		4		5		6		7	
		Trs	Vol.	Trs	Vol.	Trs	Vol.	Trs	Vol.	Trs.	Vol.	Trs	Vol.	Trs	Vol.
Clover Sta.	16	86	1,455	62	724	26	1,715	40	1,736	178	31,696	43	330	21	215
Clover Sta.	36	95	1,260	55	600	50	3,148	66	3,148	205	33,243	37	286	31	357
Aspen Lake	34	47	659	34	492	39	2,785	75	5,745	142	24,894	10	83	12	107
Eagle Ridge	16	71	811	65	542	36	1,915	50	2,101	146	20,431	22	103	7	69
Jenny Creek	33	46	380	38	255	27	971	39	1,526	68	8,086	7	41	13	107
Jenny Creek	34	37	312	12	70	38	2,047	29	944	61	8,714	8	40	15	126
Johnson Pra.	7	33	768	35	713	16	2,070	26	2,443	124	46,045	-	-	5	93
Klamath Cr.	9	16	120	6	32	14	384	10	452	10	903	2	14	2	9
Pokegama	36	43	350	17	148	20	1,133	14	495	83	12,835	-	-	12	108
Round Lake	5	69	766	14	129	19	974	11	583	90	13,522	2	8	9	71
		543	6,881	338	3,705	285	17,142	360	17,173	1107	200,369	131	905	127	1,262
Av. Volume			13		11		60		48		180		7		10
Tot.Vol.onPlot			344,050		185,250		857,100		858,650		10,018,450		45,250		63,100
Bugs			365		1,362		4,058		23,391		135,539		135		2,206
			344,415		186,612		861,158		882,041		10,153,989		45,385		65,306
			2.7+		1.5		6.9		7.0+		81.0		.4		.5

Total - 2891 trees 12,538,906 bd.ft.

TABLE 9.—Data for Plate IV

Area 1 - Bug Trees

		1		2		3		4		5		6		7	
		Trs	Vol	Trs	Vol.	Trs	Vol.	Trs	Vol.	Trs	Vol.	Trs	Vol	Trs	Vol.
Aspen	34	1	8	25	405	7	306	17	892	47	8,335	-	-	9	115
Clover	16	2	14	9	74	3	60	51	3,051	96	16,459	5	27	16	120
Clover Sta.	36	5	21	8	75	3	95	21	1,369	58	9,477	2	24	15	160
Eagle Ridge	16	-	-	14	311	5	307	53	1,839	103	17,832	4	23	22	198
Jenny Creek	33	7	56	2	24	27	852	63	2,183	52	6,729	2	16	10	86
Jenny Creek	34	8	66	3	38	20	800	94	3,749	155	12,554	3	18	65	630
Johnson	7	-	-	1	40	1	9	10	741	44	8,538	1	14	9	189
Klamath C.	9	10	157	10	75	20	473	36	1,131	60	4,857	-	-	11	89
Pokegama	36	4	35	2	13	17	682	83	2,476	189	21,733	-	-	31	328
Round Lake	5	5	48	11	307	19	475	78	5,960	176	29,045	2	13	22	291
		40	365	85	1362	122	4058	506	23,391	980	135,539	19	125	210	2,206
Av. Volume			9		16		35		46		138		7		10
			.22		.8		2.4		14.0		81.2		.1		1.3
Ratio			.08		.5		.35		2.0		1.0		.25		2.6

Total - 1962 trees   167,056 bd.ft.